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Technological constraints to firm performance: the moderating effects of firm linkages and cooperation

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1. Introduction

In many African countries, SMEs play significant roles in terms of their contributions to job creation and poverty alleviation. However, their productivity and competitiveness have been hindered by inadequate access to, and low uptake of, technological innovations (Agwu, 2014; Okpara, 2011). Innovation uptake provides firms with competitive advantage (Hult et al., 2004), and innovation strategy should therefore be an integral component of an overall business strategy (Gunday et al., 2011). However, in African contexts, firms face peculiar challenges and constraints associated with latecomer contexts, in terms of lower technological capabilities, low market development and inadequate knowledge base (Lee and Lim, 2001). These challenges are exacerbated by a lack of adequate governmental commitment and necessary policy interventions to fix key infrastructures and support diffusion of technological innovations among firms. Given the intensity of environmental turbulence and the near-absence of institutional support and policy incentives, many African firms struggle to survive, and surviving firms often struggle to grow (for studies on African firms, see Egbetokun, Siyanbola, Olamade, Adeniyi, & Irefin, 2008; Oyelaran-Oyeyinka, B. & McComick, 2007).

Interfirm networking is one of the main strategies employed by firms to overcome constraints to technological innovation (Love and Mansury, 2007). Interfirm cooperation has gained more attention in the past three decades due "to the increased pace of technological development, the rising complexity and variety in knowledge necessary for technological innovation, the trend towards the fusion of disciplines in previously separate fields, and the need to share research and development costs"(Fischer and Varga, 2002, pp.725). Cooperation activities provide firms with access to complimentary technological resources

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(De Faria et al., 2010) and also enable cost sharing, risk reduction and flexibility in the drive for value creation (Lavie, 2007). These network activities can take the form of informal linkages aimed at specific needs or short term goals (Lavie, 2007; Mancinelli and Mazzanti, 2009), or formal alliances aimed at long term objectives (Holmen et al., 2005; Schilling and Phelps, 2007).

Given the peculiar challenges associated with the African context, it is important to fill the gap in empirical data about the impact of inter-firm networking among SMEs in sub-Saharan Africa. How do firms cooperate and collaborate, and does it make a difference? Nigeria presents an archetypical context to examine the coping strategies of African firms with regard to technological innovation and firm performance in a challenging environment. First, Nigeria is the most populous nation in Africa, and it is also one of Africa's biggest economies. Furthermore, it is also a window to Africa's ethnic and cultural diversity, with more than 300 language groups spread across the country's various geo-political zones. Finally, Nigeria, like most African countries, is grappling with the challenges of policy instability, institutional weaknesses, inadequate infrastructure, widespread poverty and high rates of employment. This paper therefore investigates the coping strategies of Nigerian firms, specifically in terms of their mobilisation of external resources in formal and informal networks to overcome barriers to uptake of technological innovations. In particular, the paper focus on two research questions:

1. Do Technological innovations- product and process innovations- drive firm performance?
2. In what ways do inter-firm cooperation and informal networking support firms' successful uptake of technological innovations?

In order to answer these questions, this study draws from a random survey of 631 Nigerian firms to illuminate the effectiveness or otherwise of firm linkages and cooperation.

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Furthermore, it aims to provide insights on policies and interventions that may be adopted to support beneficial uptake of innovations among firms in the region. The rest of the paper is organised as follows: first a review of the literature sets out the theoretical background and hypotheses development. This is followed by a discussion of firm-level constraints to innovation uptake. Then the empirical context provides insights into peculiar challenges associated with Nigerian firms. Following this, the methods of data collection and analyses are outlined before a discussion of the results. Finally, the conclusion highlights key findings of the paper and makes recommendations on relevant policy interventions.

2. Theoretical background and hypotheses development

The theoretical foundation for this study is the model of technological innovation system figure 1) adapted from the works of Hekkert et al., (2007) and Bergek et al., (2008). Specifically, we focus on the relationships between the structural components and the functions within the system. With firms as key actors, the structural components interact in a mutually reinforcing process, and this in turn influences the performance of the functions. For the purpose of this study, we focus on the influence of networks both on the other structural components, as well as functionalities. Thus, we explore the impact of networks on the capacity of firms to overcome organisational and institutional constraints to technological innovations, on the one hand, and resource and knowledge constraints, on the other. However, in this paper, the final outcome of interest is firm performance, not the overall system effect. The empirical model is explained later in this paper.

INSERT FIGURE 1 HERE

2.1 Technological innovation, innovativeness and firm performance

A number of different approaches have been adopted by various scholars to classify innovations, with respect to the nature or types of innovations (See: Sternberg et al. 2003; Rogers 1995; Oke et al. 2007; Lin & Chen 2007). One of the best known classifications is

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provided by the OECD in the *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data* (OECD, 2005), adopted by authors such as Gunday et al. (2011). The Oslo Manual highlighted four main types of innovation: product innovation, process innovation, marketing innovation, and organisational innovation. This paper focuses attention on the two types of technological innovations: product innovation and process innovations. Product innovation is defined as "the introduction of a good or service that is new or significantly improved with regard to its characteristics or intended uses"(OECD 2005, pp. 48), while process innovations focus on new methods of producing goods and providing services, rather than the goods and services themselves.

Technological innovation contributes to firm performance through increase in labour productivity (Cainelli et al., 2004; Jones and Corral de Zubielqui, 2017), improved resource efficiency (Adams and Comber, 2013), and increased sales and profit through access to new markets (Bhaskaran, 2006). For small firms, in particular, the propensity to innovate may take on an even greater significance for firm performance and competitiveness (Rhee et al., 2010). In other words, smaller firms can make up for their resource constraints and disadvantage relative to large firms by focusing more on innovative activities, and leveraging their flexibility and proximity to the market for superior business performance (Batra et al., 2015). However, because the contributions of technological innovations to productivity often takes time, larger firms tend to have the advantage in terms of their resource capability to adopt and implement them (Abor and Quartey, 2010). Thus, the paper proposes the following hypotheses to evaluate the impact of technological innovations on firm performance:

H_1. Higher levels of product innovations are positively associated with better firm performance in terms of increase in sales.

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H_2. Higher levels of process innovations are positively associated with better firm performance in terms of increase in sales.

2.2 Constraints to technological innovation in SMEs

In order to innovate successfully, firms rely on certain resources and capabilities. These comprise financial, human, and organisational resources and capabilities (Hewitt-Dundas, 2006). The quantity and quality of resources available to firms generally depend on skilled labour, firm size, firm age, and exposure to foreign trade, among others (Oum et al., 2014). Therefore, the difference between innovative and non-innovative or less-innovative SMEs, and between high growth and low growth firms, is often explained by their different capacities to surmount or cope with constraints. These constraints can be financial, informational, market, or institutional.

2.2.1 Financial constraints

Small and medium scale enterprises face bigger obstacles, compared with large firms, in their bid to access external sources of finance, and this constraint significantly hinders their growth and operation (Beck and Demirguc-Kunt, 2006), limits their opportunities (Van Burg et al., 2012) and affect their capacity to innovate (Beck and Demirguc-Kunt, 2006). With limited finance, SMEs are, for example, often unable to acquire new machinery or equipment required to improve productivity (Oum et al., 2014).

2.2.1 Knowledge and information constraints

Firms require information about technologies and about markets in order to achieve comparative or competitive advantage (Pachouri and Sharma, 2016; Talegeta, 2014). For example, information about customer behaviours and tastes, and the associated new market opportunities can motivate firms to invest in new technologies (Oum et al., 2014). In developing countries, SMEs tend to struggle more in terms of their access to information, due

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to lack of technology transfer institution, and poor internet access (Talegeta, 2014). Also, while information asymmetry about innovation is often to the advantage of large firms (Beck and Demirguc-Kunt, 2006; Hewitt-Dundas, 2006), small firms can mitigate this disadvantage by accessing external sources of knowledge and information through partnerships with other organisations (Garriga et al., 2013; Hewitt-Dundas, 2006).

2.2.2 *Market constraints*

Market characteristics such as demand, competition, and monopoly can have major impacts on firms' technological innovation activities (Pachouri and Sharma, 2016). Technology requirements and technological innovations are often sector specific or peculiar to particular market segments. Thus, firms are under pressure to acquire technologies to cater to customer demands in particular sectors or market segments. In emerging markets, where there are high levels of unpredictability and uncertainties, firms need to adopt effective strategies to cope with the technological requirements of changing market demands (Wu, 2011). Furthermore, as firms with high market shares have incentives to pre-emptively innovate (Blundell et al., 1999), those with lower market share- typically smaller firms- have to adopt appropriate strategies to overcome their constraints.

2.2.4 Institutional and infrastructural constraints

Institutional frameworks- and the infrastructures embedded in them- vary between developed and developing countries. The challenges are different, and firms require different capabilities and coping strategies in order to compete and grow (Batra et al., 2015). For example, in developing countries with low levels of institutional and infrastructural development, firms face bigger financing obstacles because of a lack of, or weak, protection of property rights (Beck and Demirguc-Kunt, 2006; De-Soto, 2000). In addition to this, the strength or otherwise of the national innovation system also has a strong impact on the diffusion of innovations within a country. Where innovation-related institutions like

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technology parks and local technology supply sources are absent or weak, there are fewer opportunities for firms to be aware of, and take advantage of, technological innovations (Hadjimanolis, 2000).

Furthermore, unfavourable government policies and regulation can constitute a major hindrance to innovation. These include "low patent protection, absence of government R&D funding, low financial regulation assurance, low support for doing and expanding innovation, (and) low access & usage of government loan" (Talegeta 2014, pp.98).

2.3 Inter-firm cooperation and technological innovation

It is now widely acknowledged that technological innovation is as much a social process as it is a technical process (Fischer and Varga, 2002). Thus, firms typically rely on extensive inter-organisational networks and linkages to create, develop and market technological innovations. The knowledge processes leading to development of technological innovations are increasingly complex, and cooperation activities provide firms with the opportunities to access complementary technological resources (De Faria et al., 2010). Some firms have embraced the idea of "co-petition", which entails simultaneous cooperation and competition between firms (Bengtsson and Kock, 2000; Tuffa Birru, 2011). Such alliances enable rival firms to combine their resources for development of new products and technologies (Gnyawali and Park, 2009). In doing so they are able to achieve economy of scale, reduce the challenges of rising R & D costs, and mitigate high risk and uncertainty in technology development (Gnyawali and Park, 2009; Ngugi et al., 2010; Oughton and Whittam, 1997). These collaborative networks of small firms are based on the idea of social capital in its structural, cognitive and relational dimensions(Camps and Marques, 2014). Social capital enables small enterprises to promote linkages, generate synergy and achieve integration by embedding small firms in indigenous networks (Cooke and Wills, 1999). Cooperation between small firms, especially new start-ups, and large established firms can also be

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mutually beneficial. This is especially so in instances where small start-up firms are owners of new, disruptive technologies but otherwise lack the "financial, marketing and distributional resources that established firms can provide" (Shan, Walker, & Kogut, 1994, pp.388).

Different cooperation strategies can be targeted at different firm objectives and outcomes. For example, collaborative R&D may be aimed at incremental innovations to improve labour productivity, or basic R&D and client collaboration may be aimed at expanding sales for innovative products (Belderbos et al., 2004). A firm's cooperation activities can be adhoc and informal, focusing on short term goals, or it can be a formal, structured arrangement focusing on long term objectives and based on well-defined commitments from partners (Lavie, 2007; Mancinelli and Mazzanti, 2009; Schilling and Phelps, 2007). In some arrangements, cooperation may not be aimed at developing competencies among firms, but rather the ability to access such competencies (Hanna, 2007). The success of these cooperative arrangements typically depend on factors such as trust, communication and reciprocity, commitment of senior managers, well documented agreements between firms, and safeguards in place for protection of core technologies (Chen and Karami, 2010). Furthermore, interfirm cooperation and learning is usually enhanced by geographical proximity, for example of firms in industrial clusters (Felzensztein and Gimmon, 2008), and structural proximity to other firms in the network (Lee et al., 2015).

Inter-firm alliances can be instrumental for diversification of a firm's technological base, and thus enhance innovation efficiency and competitive advantage (Huang and Chen, 2010). However, an over-abundance of network-level technological diversity can precipitate negative synergies and have negative impact on firm innovation (Yu, 2013), for example through increased coordination costs and the heavy costs of integrating technological knowledge across disciplinary frontiers (Lin et al., 2006). This paper therefore proposes the

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following hypotheses regarding the impact of firms' cooperation activities on constraints to uptake of technological innovations:

H_3. A firm's formal cooperation activities significantly moderate cost, knowledge, market and infrastructural constraints to uptake of technological innovations.

H_4. A firm's informal linkages significantly moderate cost, knowledge, market and infrastructural constraints to uptake of technological innovations.

The four hypotheses examined in this study are summarised in the conceptual model shown in figure 2 below.

INSERT FIGURE 2 HERE

3. Empirical context

Nigeria is an archetypical context for a study of African firms. With an estimated population of 186 million (United Nations, 2016), it is Africa's most populous nation. It is also reputed to be one of African's largest economies. According to the recent available statistics, about 71% of the population are reported to be living in relative poverty, and poverty rate has been put at 64.2% in 2013/2014, increasing from 62% in 2010 (World Bank, 2013). Moreover, the official unemployment rate increased from 11% in 2006, to 24% in 2011, and a great number of those employed are under-employed (Rogers, 2012). According to a 2014 report, the number of workers in vulnerable employment was very high at 77% in 2012, and labour productivity remains very low (International Labour Organization, 2014). Small and medium scale enterprises, which constitute more than 90% of businesses in Nigeria (The Economist Intelligence Unit, 2015), are considered critical for the country's goals of sustainable growth, poverty reduction and job creation. The Nigerian Federal Government reports that 17,284, 671 micro, small, and medium scale enterprises (MSME) in Nigeria, with the vast majority of

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them classed as micro enterprises. Together they contribute about 75% of employment, and about 40% of the country's GDP (Federal Government of Nigeria, 2013).

While, there is no single universally accepted definition of small and medium scale enterprises (SMEs), most definitions and classifications of SMEs are based on three main criteria: number of employees; firm turnover, and value of assets (European Comission, 2005; Federal Government of Nigeria, 2013; Gibson and Vaart, 2008). In this paper, we adopt the number of employees as the main criteria to classify the firms, using the template proposed in the Nigerian National Enterprise Development Programme (Federal Government of Nigeria, 2013). While assets and annual turnovers are also important indicators of firm size, they are, unlike employee headcount, often limited in their international application, even in developing country contexts. For example, the assets criteria for a medium scale enterprise in Thailand may be several times the assets requirement for medium scale enterprises in Tanzania, as Thailand's GDP is 9 times that of Tanzania (The World Bank, 2016).

The growth and performance of SMEs in Nigeria have been hampered by, among other things, lack of financing, poor infrastructure, inadequate access to machinery and spare parts, low access to raw materials, and lack of access to research facilities (Ehinomen and Adeleke, 2012; Mambula, 2002). Their competitiveness is also limited by deficiencies in human capital and entrepreneurial capacity (Abiodun, 2015). Furthermore, Nigeria's SMEs are generally limited in their capability to manage risks, including financial risks associated with fluctuations in the capital market, financial market, and commodity market; operational risks arising from product failure and management fraud; and strategic risks related to competition, customer preference and policy issues (Yusuf and Dansu, 2013).

As highlighted in the foregoing, access to adequate financing is a major constraint for Nigeria's SMEs. Majority of start-up funds are derived from personal savings and assistance

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from family and friends, with less than 5% of start-up funds obtained from financial institutions (Federal Government of Nigeria, 2013). Furthermore, bank lending rate is high-between 25 to 30%. According to a 2012 report, less than 1% of SMEs have had access to bank finance in the previous three years (Federal Government of Nigeria, 2013). As of 2011, a 6-year average of commercial bank loans to SMEs represented only 0.41% of total credit (Central Bank of Nigeria, 2014). These were in spite of a federal government scheme in which 200 billion naira fund was provided to "fast-track the development of the manufacturing SME sector of the Nigerian economy by providing guarantee for credit from banks to SMEs and manufacturers" (Central Bank of Nigeria 2010, pp. 1).

In addition to the challenge of limited access to credit, operating cost for SMEs in Nigeria is very high, mainly due to the lack of constant power supply in the country. Firms have to generate their own power using alternative means, and this significantly increases production costs and reduces profit margins for firms, especially in the manufacturing sector (Federal Government of Nigeria, 2013). The most recent enterprise survey by World Bank indicated that, among other things, the electricity problem has worsened between 2007 and 2014, with number of electrical outages increasing from 25 to 32, and firms incurring greater losses due to electrical outages (Table 1). In 2010, Nigeria modest energy demand projections, to maintain a 7% GDP growth, was set at 28,360MW for the year 2015 (Sambo et al., 2010). However, as of October 2016, the peak power generation was 2687.2MW (Federal Ministry of Power Nigeria, 2016). In addition to the direct impact on operation cost, inadequate power supply significantly limits SMEs capability to access, adopt, and benefit from innovations, as these innovations, such ICT innovations, relies heavily on electric power supply (Nyakuma et al., 2016).

INSERT TABLE 1 HERE

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Over the years the Nigerian government has launched a wide range of policy initiatives to address the pressing needs of small and medium scale enterprises in the country. For example, the Small and Medium Enterprises Development Agency of Nigeria (SMEDAN) was established to help stimulate, coordinate and monitor the development of the sector. This is in addition to the work of the Corporate Affairs Commission (CAC), mandated to regulate the formation and management of companies in Nigeria, and the Bank of Industry, whose core responsibility is to provide financial assistance to SMEs and support the expansion, diversification and modernisation of existing enterprises (Federal Government of Nigeria, 2013). However, the impact of these governmental and policy interventions has been limited. In some cases, the SME owners are not aware of the existence of government interventions (Jibrilla, 2013). Furthermore, the impact of the various initiatives have been hampered by poor implementation, bureaucracy and administrative bottlenecks, erratic financing of credit schemes initiated by governments, and the difficult conditions often set by banks and credit agencies for SMEs (Oni and Daniya, 2012).

4. Method

4.1 Sample and data collection

The data used for this study was drawn from the Nigeria's national innovation survey conducted by the National Centre for Technology Management, an agency of the Nigerian government under the Federal Ministry of Science and Technology. The survey, carried out in partnership with African Union's "The New Partnership for Africa's Development (NEPAD), was undertaken during the three-year period between 2008 and 2010. The survey instrument incorporated the guidelines from the Oslo Manual for collecting and interpreting innovation data (OECD, 2005). The data was collected using multi-stage, stratified random sampling of 1,500 manufacturing and services firms. The population for the enterprises is the national database of 18,906 firms obtained from the National Bureau of Statistics (NBS). In

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order to ensure representativeness of the sample, the firms were stratified by sector and size using appropriate strata weights. In sectors with new firms, a higher proportion of firms was selected into the sample. In sectors with a relatively large number of firms, proportional probability sampling was used. Out of the 1,500 questionnaires sent out, 802 were completed. Following data cleaning, 631 completed questionnaires were deemed usable for analysis. This represents a final response rate of 42.1%.

In addition to general information such as staff strength and firm sales, firms were asked to provide information about their adoption of new or improved products that are already in their sector or industry but new to their enterprises, as well as product innovations new to their sector. In the survey, the term "product" was used to incorporate both goods and services. Similarly, information was elicited about process innovations, defined as "the use or implementation of new or significantly improved process or method for the production of goods or services or supporting activity" (National Centre for Technology Management, 2012). Furthermore, information was sought about the firms' cooperation with other enterprises or non-commercial partners, and the external linkages they have employed to access information towards their enterprises' innovation activities. In addition, the respondents were asked to provide about cost, knowledge, market and other factors that have hampered their innovation activities or influenced their decision not to innovate.

4.2 Dependent variables

4.2.1 Sales increase

Firm performance is a complex and multi-dimensional construct which has been measured using a range of objective and subjective indicators including profit, return on investment, sales growth, number of employees survival, reputation, etc. (Chittithaworn, 2011). Of these, sales growth and profitability are the most widely used measures (Jones and Corral de Zubielqui, 2017). In this paper, we computed increase in annual turnover as a measure of firm

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performance, following Dess and Robinson (1984) and Zahra (1993). First, the percentage increase in the firm's sales was computed using the reference years of 2010 and 2009, that is, increase in turn over from the previous year. The resulting scale data, ranging from 0 to 99%, were then recoded into dichotomous variable. Thus, firms with less than 1% increase in sales were reset as 0 and those with more than 0.99% increase were reset as 1, with 0 indicating no increase in sales and 1 indicating increase in sales.

4.3 Independent variables

4.3.1 Product innovation

Product innovation is defined as "the introduction of a good or service that is new or significantly improved with regard to its characteristics or intended uses"(OECD 2005, pp. 48). In resource-poor environments, product innovation can be undertaken by exploring existing resources in new ways through a process referred to as bricolage, or through improvisation to make up for scarce time , or through frugal engineering that seeks to minimise costs (Cunha et al., 2014). In this study, firms were asked, on a binary scale of 0 and 1, if their enterprise introduced new or significantly improved goods during the reference period, 2008 to 2010. The same question was asked about new or significantly improved services. The aggregate scores were then computed to measure the presence or extent of product innovation in the firm.

4.3.2 Process innovation

Process innovations focus on new methods of producing goods and providing services, rather than the goods and services themselves. The aim of process innovations may be to "decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products" (OECD 2005, pp. 49). In effect, process innovations are new tools, devices and knowledge that mediates between inputs and outputs (Gopalakrishnan et al., 1999). While some authors have employed Likert-scale items to measure the extent of

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firms' process innovations (Gunday et al., 2011), this study used binary scales across a range of items covering improvement in methods, logistics and supporting activities. In line with the recommendations in the Oslo Manual (OECD, 2005), respondents were asked if their firms have introduced new or significantly improved methods of manufacturing or producing goods or services, new or improved logistics, as well as supporting activities. As for product innovations, the aggregate scores for the question items were computed for each firm, as an indicator of their level of process innovations.

4.3.3 Firm type

From the information obtained from respondents about the size of the workforce, we computed a new variable "firm type" by grouping the firms into four types based on the criteria set up in the Nigerian National Enterprise Development Programme (Federal Government of Nigeria, 2013). Thus, firms with less than 10 employees were classified as micro enterprises; those 10 to 49 employees classed as small enterprises; those with 50 to 199 employees classed as medium scale enterprises; and those with 200 or more workers were grouped as large firms.

4.3.4 Barriers to innovations

Innovation barrier was measured as a multi-dimensional construct incorporating cost factors, knowledge factors, market factors and infrastructure factors (see the literature review for detailed exploration of these barriers to innovation uptake). This provides a more robust measure, better than each of the dimensions taken singly. Using a series of Likert scale items on a scale of 0 for "not experienced" to 3 for "high", the firms were asked to rank the importance of the factors in hampering their innovation activities or influencing their decision not to innovate. The aggregates for each of the four dimensions were then computed individually, before a gross aggregate was computed to indicate overall barrier to innovation.

4.3.5 Firm cooperation

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To measure cooperation for innovation, the firms were first asked if they cooperated with any partner on any of their innovation activities during the years between 2008 and 2010. Then they were asked to indicate, in series of yes or no question, whether they engaged in cooperation with any of the following categories of possible partners: other enterprises within their group, suppliers, clients or customers, competitors, consultants, universities or other HE institutions, and government research institutions. The binary responses are then summed, following the example of Fındık & Beyhan (2015). The aggregates of the scores for all the relevant partners provided an indication of the level of firm cooperation for their innovation activities.

4.3.6 Firm linkages and information sources

In addition to firm's cooperation with other partners, the respondents were also asked to identify their sources of information, and how important those sources of information were to their innovation activities. Likert scale items were again used on a scale of 0 to 3, and sources were categorised under four groups: internal sources, market sources, institutional sources and other sources. Once again, scores for each group was computed first, before an aggregate score was computed for all information sources, as a measure of overall firm linkage.

4.3.7 Interaction terms

In our regression model, we used the following interaction terms: innovation barriers by firm cooperation; and innovation barriers by firm linkages. This enables us to evaluate the possible moderation effects of firm cooperation, and then firm linkages and external sources of information, innovation barriers, with respect to the dependent variable.

4.4 Analysis

Logistic regression was used to model the probability that the binary response (0= no sale increase and 1= sale increase) is a function of a set of five predictor variables: product

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innovation, process innovation, firm type the interaction of firm cooperation with firm cooperation, the interaction of firm linkages with innovation barriers; and their respective regression coefficients β_1, β_2, β_3, β_4, and β_5. The general form of the binary logistic regression is given as:

$$Y = ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

Therefore, the probability is given as:

$$P = \frac{e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_2 X_4+\beta_5 X_5}}{1+e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_2 X_4+\beta_5 X_5}}$$

Where: X_1 represents level of product innovation

X_2 represents level of process innovation

X_3 represents firm type

X_4 represents the interaction between firm cooperation and innovation barrier

X_5 represents the interaction between firm linkages and innovation barrier

And e^{β} is the odds ratio

The binary logistic model was run on SPSS Vs 20, while the marginal effects were calculated using the "mfx" package on the R software (Torres-Reyna, 2014). Following the recommendation of Peng et al. (2002), we assessed the soundness of our model using the following criteria: a) overall model evaluation using the Nagelkerke R^2, providing an indication of the explanatory power of the model ; b) statistical tests of individual predictors using the likelihood ratio test; c) goodness-of-fit statistics using the Hosmer and Lemesow test. This is performed by dividing the predicted probabilities into deciles and then comparing the Pearson Chi Square of the predicted frequencies to the observed frequencies; and d)

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validations of predicted probabilities using the classification table. The results of the regression model are presented and discussed in the following section.

5. Results and discussion

5.1 Descriptive statistics

As summarised in table 2, the vast majority of the firms are small and medium scale enterprises, and about three-fifths of them are manufacturing firms. Overall, a considerable percentage of the firms- generally more than 40%- have engaged in some innovation activities, both for product and process innovations. However, only 30% of the 387 respondent firms have engaged in some cooperation with other enterprises and non-commercial institutions.

The descriptive statistics in table 3 indicates a mean firm age of 14.67, implying that the firms are generally established enterprises. A mean staff strength of 180 is also consistent with the medium-scale profile of majority of the firms, and 39% percentage of the staff hold degree qualifications.

INSERT TABLE 2 HERE

INSERT TABLE 3 HERE

The correlation matrix in table 3 reveals a significant correlation between the innovation variables- product and process innovations- and firm performance (measured by sales increase) as well as firm linkages. In order to correct for endogeneity associated with these correlations by controlling for the innovation variables, the logit model was run in two stages. Details of the regression model are provided below.

5.2 Regression model

The results of the logistic regression are presented in table 4. In order to correct for biased estimation arising from the correlation of the innovation variables (product and process

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innovations) with firm performance, the logit model was run in two stages on SPSS, followed by a calculation of the marginal effects on the R software. In the first stage of the logit model, product innovation, process innovation and firm type were incorporated into the model. In the second stage, the interaction terms- cooperation/barriers and informal linkages/barriers- were added into the logit model. The Nagelkerke R^2 indicates that the final (stage 2) model explains 30.5% variation in firm sales, compared with 16.3% for the stage 1 model. This indicates that model 2 is a significant improvement on the initial model, and the inclusion of the moderation effects represents a more powerful explanation of changes in firm performance. Next we explore the overall model evaluation. The Hosmer & Lemesow test indicates that the stage 2 model has a better overall fit, with a low χ^2 value of 2.795 and a non-significant p of 0.903 ($p > 0.05$), compared with a χ^2 of 6.386 and a p-value of 0.495. In The likelihood ratio test, indicates that the stage 2 model with a p-value of 0.001 is an improvement on the earlier stage 1 model with a p-value of 0.013. Finally, the classification table (table 7) shows that the sensitivity is 40%, the specificity is 90.9% and the overall correct prediction of 72.9% represents an improvement of 32.9%

INSERT TABE 4 HERE

INSERT TABLE 5 HERE

The inspection of the coefficients in table 4 and the marginal effects in table 5 indicates that product innovation has a significant positive relationship to increased firm sales. The same is true for process innovation. Therefore, the hypotheses H_1 and H_2 are supported. Furthermore, the results show that the interaction between aggregate innovation barrier and firm cooperation is positively significant for increased firm sales, thereby confirming hypothesis H_3. Conversely, the interaction between innovation barrier and firm linkages and external information sources is not significant in our model. Therefore, hypothesis H_4 is not supported

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in our model. Finally, the model indicates that firm type is not a significant predictor of increased firm sales.

INSERT TABE 6 HERE

5.3 Discussion

The findings of our study about the positive impact of product innovations on firm performance is consistent with much of the literature (see, for example, Gunday et al. 2011; Akgün et al. 2009; Löfsten 2014; Verhees & Meulenberg 2004). This is because the creation of new products and services, or improvement of existing ones, contributes directly to better customer satisfaction, as well as helping to attract new customers and increase demand. Furthermore, a firm's ability to create new products can be critical for future income and firm survival, as it helps them to keep up with increasing competition and the challenges associated with shorter product life cycles. Also, process innovation is found to have positive impact on firm performance, consistent with the findings of Gunday et al. (2011), who also observed that process innovations and product innovations are mutually reinforcing. Our findings reinforce the view that improved or new processes usually leads to the development of new or better products. With new processes and new and better products, firms are more able to retain their existing customers and expand their market reach, thereby enhancing sales and profit.

As outlined in section 4.3.4, other barriers faced by Nigerian SMEs include knowledge barriers, market barriers and infrastructure. Given the resource constraints of the firms and the capital intensive nature of the industries, the ability of a firm to benefit from successful adoption and implementation of product and process innovations depend on how well they are able to mobilise external resources to overcome or mitigate barriers to innovation. Therefore, our study explored how cooperation and external linkages interact with aggregate innovation barrier. Our findings show that formal cooperation moderates innovation barriers

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so that firms with strong cooperative networks are able to effectively use innovations to drive up sales. Formal collaboration and networking enables firms to achieve economy of scale, as well as complement one another with diverse competencies, skills and technologies.

This study took into account the fact that firm cooperation occurs at many levels. These include: inter-firm cooperation, exemplified by cooperation with customers and suppliers; cooperation with intermediary institutions like universities and research institutes; and cooperation with government agencies (Zeng et al., 2010). Firm cooperation also differs in terms of firms' aims and objectives, whether it is for joint production, information sharing, or research and development (R&D).

Our study also shows that, unlike formal cooperation, firm linkages and external sources of information is not an effective moderator of innovation barriers with respect to increased turnover for the firms. This may reinforce the idea that firms with strong cooperative networks with a wide spectrum of partners do not require other external sources of information in order to bolster their innovation activities, because their collaborative networks already serve as effective sources of information. Compared with formal cooperation with various partners, firm linkages tend to be less structured and less defined, with minimal commitments and obligations from parties involved. Moreover, firms require more than just information in order to overcome cost, knowledge, market and infrastructure barriers to innovation. As highlighted in the foregoing, formal collaboration provides, in addition to information, shared skills and technologies, shared risks, and improved access to capital. Furthermore, it enables firms to lower production costs by outsourcing locally and maintaining leaner inventories.

6. Conclusion

The study affirms the findings of other scholars that product and process innovations are significant contributors to firm performance, and firms with higher levels of innovation

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activities tend to achieve increase in sales. However, this study also shows that, in order to mitigate or overcome constraints, more successful firms often rely significantly on cooperative alliances and collaborative networks. These partnerships with suppliers, competitors and intermediary organisations enable firms to reduce risks, share skills and technologies, and achieve better access to capital, among other things. Therefore, firms need to be more pro-active and strategic in choosing and maintaining alliances and partnerships. For example, in a multi-ethnic society like Nigeria, firm success may hinge significantly on the capacity of firm managers to reach out across ethnic divides. This can help firms gain information advantages about customer preferences and product needs in different cultural contexts, and also expand their options to overcome resource constraints, among others.

Given the evidence presented in this paper about the effectiveness of cooperative networks, governments can develop specific interventions to incentivise inter-firm cooperation, including enablement of better access to credit, and market reform. Furthermore, there is a need for governments to do more in terms of bottom-up approach to interventions, in affirmation of co-creation capacities of firms. Specifically, governments can do more to work with umbrella organisations, firm cooperatives, and commodity associations to better understand the needs and provide more effective support for linkages and cooperation in the supply chain.

Finally, while this paper draws from firm-level data, future studies can explore implications for the role of managerial competencies and capabilities. Ultimately, individuals with decision making powers drive the firms. Senior managers are responsible for decisions about cooperation and networking; investments in innovation; levels of risk; and overall staff capacity development, among others. There is therefore a strong scope for further research on managerial characteristics and competencies in African contexts, and how these influence firm innovativeness and performance. Furthermore, in addition to nationwide surveys, there

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is a need for sectoral studies to illuminate sector-specific challenges and opportunities for innovation and improved productivity and profit in Africa.

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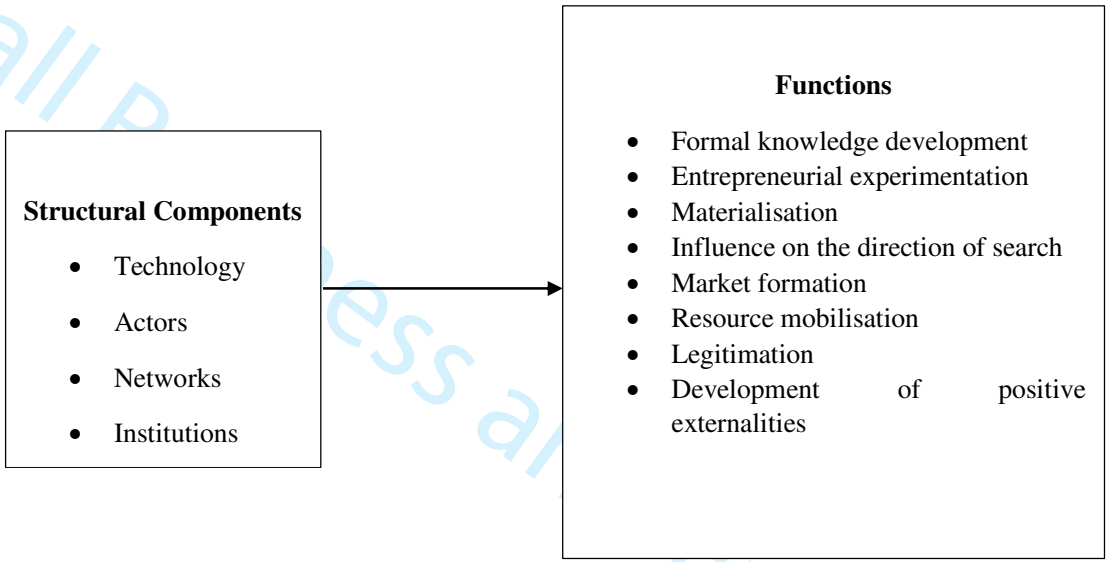

Figure 1: Structural components and functions in technological innovation system (adapted from Hekkert et al., 2007 & Bergek et al., 2008)

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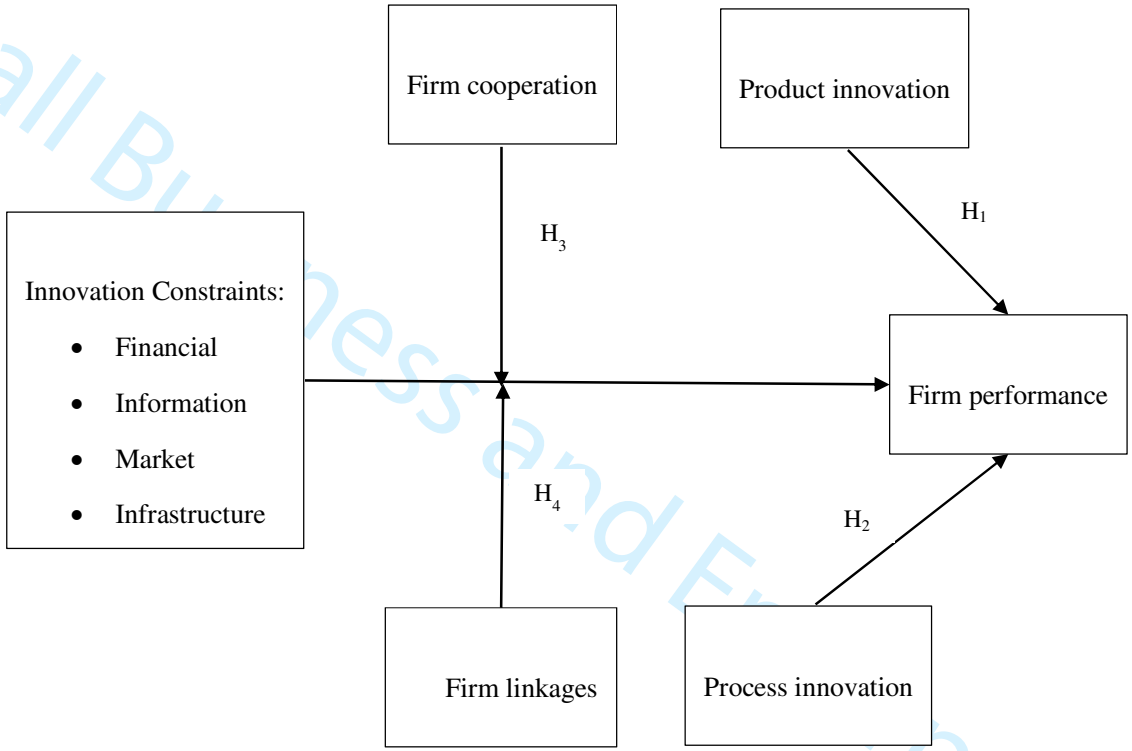

Figure 2: Conceptual model

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Table 1: Nigeria enterprise survey [data source: World Bank, (2016)]

Indicator	2007	2014
Age of the establishment (years)	9.6	15.9
Bribery index (% of gift or informal payment requests during public transactions)	30.1	26.0
Capacity utilization (%)	66.8	74.0
Days of inventory of main input	10.6	13.0
Days to clear direct exports through customs	7.5	6.0
Days to clear imports from customs	12.8	8.7
Days to obtain a construction-related permit	10.6	16.5
Days to obtain an electrical connection (upon application)	7.5	9.4
Days to obtain an import license	22.3	18.8
Days to obtain an operating license	12.1	14.4
Duration of a typical electrical outage (hours)	7.8	8.0
If a generator is used, average proportion of electricity from a generator (%)	60.9	58.8
If the establishment pays for security, average security costs (% of annual sales)	2.6	8.7
If there were losses, average losses due to theft and vandalism (% of annual sales)	4.1	13.6
If there were outages, average duration of a typical electrical outage (hours)	8.2	11.6
If there were visits, average number of visits or required meetings with tax officials	3.7	3.7
Losses due to electrical outages (% of annual sales)	8.5	10.8
Losses due to theft and vandalism against the firm (% of annual sales)	4.1	1.8
Number of electrical outages in a typical month	25.2	32.8
Number of permanent full-time workers	16.2	15.8
Number of permanent non-production workers	2.7	4.8
Number of permanent production workers	16.8	11.4
Number of permanent skilled production workers	9.6	8.4
Number of permanent unskilled production workers	8.6	2.3
Number of temporary workers	1.9	1.6

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Table 2: Profile of firms

Variable	Frequency	Percentage	Cumulative %
Firm size			
Micro enterprise	12	1.9	1.9
Small enterprise	454	71.9	73.9
medium enterprise	107	17	90.8
Large firms	58	9.2	100
Total	631	100	
Sector			
Manufacturing	371	58.8	58.8
Service	260	41.2	100
Total	631	100	
Innovation: new or sig. improved goods			
Yes	242	41.8	41.8
No	337	58.2	100
Total	579	100	
Innovation: new or sig. improved services			
Yes	230	40.9	40.9
No	332	59.1	100
Total	562	100	
Innovation: new or sig. improved production method			
Yes	299	51.1	51.1
No	286	48.9	100
Total	585	100	
Innovation: new or sig. improved logistics, delivery & distribution			
Yes	271	47.4	47.4
No	301	52.6	100
Total	572	100	

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Innovation: new or sig. improved support activities			
Yes	252	44.8	44.8
No	311	55.2	100
Total	563	100	
Cooperation for innovation			
Yes	114	29.5	29.5
No	273	70.5	70.5
Total	387	100	

Table 3: Descriptive statistics and correlation matrix

	Mean	S.D.	1	2	3	4	5	6	7	8
Sales Increase (1)	0.29	0.453	1							
Increase in employees (2)	0.81	0.389	.044	1						
Firm Cooperation (3)	4.88	4.23	.310**	.117	1					
Firm linkages (4)	12.05	5.262	.196**	.194**	.452**	1				
Product Innovation (5)	0.78	0.829	.126**	.004	.014	.132*	1			
Process Innovation (6)	1.36	1.264	.250**	.174**	.113	.321**	.546**	1		
Firm age (7)	14.67	13.382	-.174**	-.056	-.091	-.055	.117**	-.005	1	
Firm type (8)	2.33	0.667	.038	.006	.151	.063	.140**	.055	.374**	1

*p ≤ 0.05; **p ≤ 0.01; n=631

Table 4: Logistic regression analysis of firm performance

Predictor	β	SEβ	Wald's χ^2	*df*	*p*	e^{β} (Odds ratio)

Stage 1						
Product_Innovation	0.715	0.366	3.806	1	0.051	2.044
Process_Innovation	0.64	0.296	4.666	1	0.031	1.896
Firm_type	-0.328	0.356	0.849	1	0.357	0.72
Constant	-2.149	1.272	2.852	1	0.091	0.117
Stage 2						
Product_Innovation	0.868	0.405	4.595	1	0.032	2.383
Process_Innovation	0.692	0.328	4.444	1	0.035	1.997
Firm_type	-0.508	0.388	1.713	1	0.191	0.602
Firm_cooperation by Innovation_barriers	0.033	0.014	5.547	1	0.019	1.034
Firm_linkages by Innovation_barriers	0.001	0.007	0.015	1	0.903	1.001
Constant	-3.233	1.541	4.404	1	0.036	0.039

Tests		$\chi 2$	*df*	*p*
Likelihood ratio test	Stage1	10.726	3	0.013
	Stage2	21.329	5	0.001
Hosmer & Lemesow Goodness of fit test	Stage1	6.386	7	0.495
	Stage2	2.795	7	0.903

Overall Model Summary	-2 Log likelihood	Cox & Snell R^2	Nagelkerke R^2
Stage 1 model	99.646	0.119	0.163
Stage 2 model	89.043	0.222	0.305

Table 5: Marginal effects

	dF/dx	Std.Err	z	P>|z|
Product_Innovation	0.19535153	0.09162006	2.1322	0.03299*
Process_Innovation	0.15557805	0.07231022	2.1515	0.03143*
Firm_Type	-0.11423984	0.08732201	-1.3083	0.19079
Barriers_Coop	0.00749018	0.00329953	2.2701	0.0232*
Barriers_linkages	0.00019156	0.00157431	0.1217	0.90316

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 6: Classification table for observed and predicted frequencies of firms' sales' increase by logistic regression (with a cut off of 0.05)

Observed	Predicted		% Correct
	No sales increase	Sales increase	
No sales increase	50	5	90.9
Sales increase	18	12	40

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Overall % correct	72.9

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